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Hands-on Optics: Training Courses for School Teachers

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Introduction

Science teaching at all school levels should be generalised and rendered more effective in order to guarantee a strong and sustainable improvement of Science and its technological applications while improving and extending scientific literacy in our societies [1]. All over the world this is being, fortunately, accepted by governments and civil society institutions. Europe calls for more Science and Technology graduates trying to achieve the targets set in Lisbon Strategy to make the European Union "the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010" [2-5].

These demands add increasing pressure to the school and to school' teachers. Science teachers in particular face higher demands. In these troubled times students and teachers themselves (all of you in fact…), can hardly foresee a future coherent career, teachers must find ways of attract [6] and engage the students into the learning process. Informal and non-formal activities can have a very positive impact [7-8] but in-classroom activities are fundamental and here a hands-on investigative experiments based active learning is fundamental [9]. Unfortunately frequently our science teacher were trained in an essentially theoretical way and are not used to perform experiments and even less to induce or even allow the students to act hands-on, not being taught to understand the process or trained for it.

Light, Optics and Photonics have a crucial importance in our lives and to the prospects of development of our world with breathtaking developments in many different fields, including fibber optics sensor and communications, image acquisition and processing, lasers, photodynamic therapy, real time holography, optical computing, solar energy conversion and light sources… There is a lot of on-line information provided by universities, museums,... that can be directly employed by teachers [10-18].

On these lines we have developed and are running training courses [19] on hands experiments teaching approaches. The general objectives of these Hands-on Optics, supported by the European Commission (Life Long Learning/ Comenius action) are to provide schoolteachers from basic to secondary and vocational

schools strong effective knowledge on the basics of optics, focusing on an intensive training in the execution of hands-on experimental activities on the major optics subjects. Hands-on/minds-on skills will be developed allowing the teachers to organise experimental activities in their class in a confident and effective way (Fig. 1). So protocols for searching proper information related with the main topics covered during the course are given in such a way that selected hands-on optical activities can be carried out in an independent way in the future [for example, 20-25].

Methodology

The early as possible in their education the students should introduced to and get acquainted with basic optics concepts as those related to the nature of light, the subjects of general optics, geometrical physical and quantum, but also with advanced subjects of utmost importance and actuality as wave guidance, fibre optics and telecommunications, image digitalization and processing, light production and energy conversion, optical processing and computing,…

Not only specific knowledge must be acquired but also and specially the ability of exploring reasoning, acting interactively to be able to find, analyse and solve new interdisciplinary problems, should be explored and enhanced as extensively as possible.

The best way of achieving an effective sound education of the students on these optics issues is by inducing the students to an active committed participation in the teaching/learning process, through investigative practice and experimentation, making use of the new instruments and resources of the Information Society. Although a strong focus should be put into these hands-on approaches the theoretical perspective should not be forgotten and introspective abstract reasoning activities should be allowed, in particular if the characteristics of a student or group of students advise it. Constructivism [26] construcionism [27] and conceptual learning [28] among many other approaches should be explored.

The structure of Hands-on Optics training course

Although there will be a theoretical introduction to the theme, the course's methodology will essentially be based on practical experimental activities hands-on/minds-on, followed by reflection and discussion. There will be a final assessment/evaluation session.

The pedagogic approach we suggest to be used relies on a functional integration of different pedagogical theories and practices namely the constructivism, conceptual learning and pro-active learning by hands on experimentation and research. Responsibility, critical reasoning and observation, method and flexibility, interdisciplinarity, volunteer self-rewarding commitment, joint efforts and teamwork, are the main keywords that should guide all pedagogical activities. Making use of the new instruments and resources of the Information Society [10-18].

The week long training course is mostly practical and strong personal interaction among the students (the physics and science teachers) and with the trainers and tutors is expected and will be encouraged (enforced…).

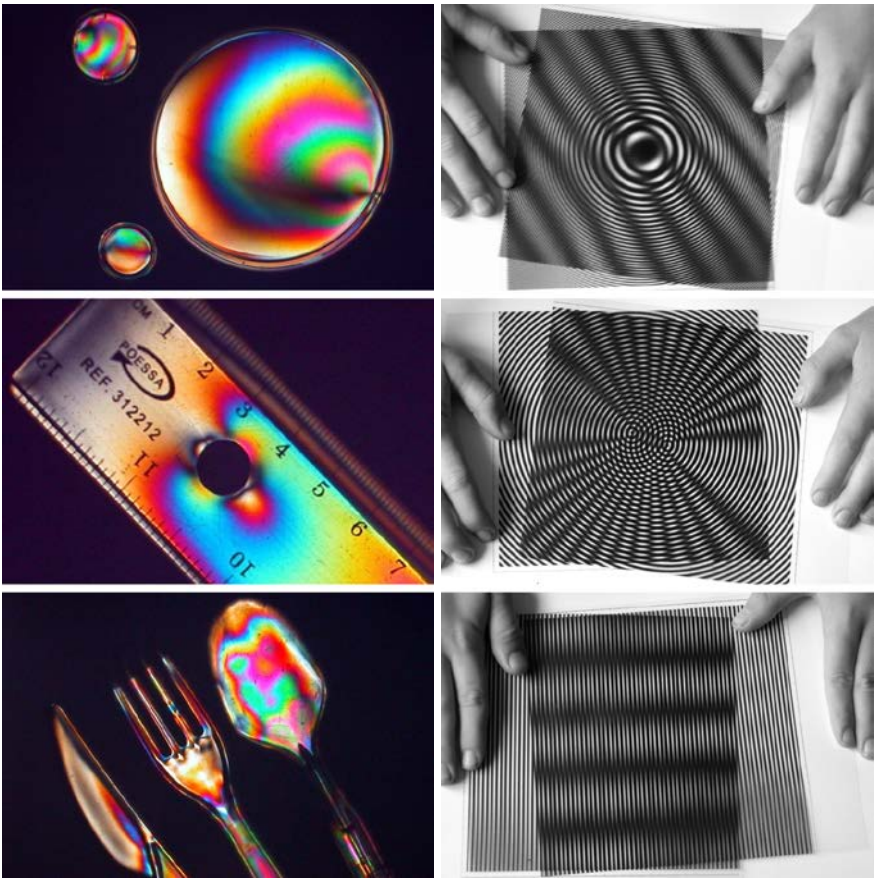

Figure 1. Hands-on optical activities: light polarization and birefringence (left) and Moiré effect (right)

We expect the teachers to act as students also in order for them to better understand the problems difficulties and behaviours of their own students.

Apart from the main curricular optics subjects we introduce lectures and workshop on transversal issues like motivational tools and activities including the resource to non-formal or informal activities. Computer modelling and simulation tools can be very useful in helping complementing or even inducing hands-on experimental works. Often teachers work “alone” and feel that way. The establishment of cooperation mechanisms among schools and teachers from the same environment but especially when coming from different countries and cultures [29] may be very important for the teachers and individuals but also as educators. This issue will also be explored specially addressing the possibilities in the frames of the EU foreseeing other opportunities (Erasmus Mundus like for instance).

1st Training Course on Hands-on Optics, April 3 to 11, 2009, Vigo, Pontevedra, Spain
&
2nd Training Course on Hands-on Optics, September 3 to 11, 2009, Braga, Portugal

Syllabus:

1st day
18:00 Registration

2nd day
9:30 Opening and presentation, M. F. Costa
10:00 Optics. Past, present and future B. Dorrio, D. Sporea, M. F. Costa,
11:30 Hands-on science P. Michaelides
14:30 Introduction to optics. The basics I. M. F. Costa, B. Dorrio, P. Michaelides
17:00 Discussion

3rd day
9:30 Constructivism. Theory and practice I S. Gatt
11:30 Constructivism. Theory and practice II S. Gatt
14:30 Introduction to optics. The basics II. M. F. Costa, B. Dorrio, P. Michaelides
18:00 Discussion

4th day
9:30 Introduction to optics. The basics III. M. F. Costa, B. Dorrio, P. Michaelides
14:30 How to organise a hands-on experiments class. The scientific method P. Michaelides
16:30 Safety issues D. Sporea
18:00 Discussion

5th day
Free day. Visits to local schools and interaction with local teachers and students

6st day
9:30 Hands-on activities I. The nature of light. B. Dorrio, C. Lima, M. F. Costa
14:30 Hands-on activities II. Color and vision. N. Tsaglotis, J Fernandes, M. F. Costa
16:30 Hands-on activities III. Reflection and refraction. J Fernandes, N. Tsaglotis, M. F. Costa
18:00 Discussion

7th day
9:30 Hands-on activities IV. Ray tracing. M. F. Costa, R. Batista
11:30 Hands-on activities V. Prims lenses and mirrors. J. Fernandes, C. Lima, M. F. Costa
14:30 Hands-on activities VI. Fiber optics, polarisation, diffraction, holography. M. F. Costa, N. Tsaglotis, C. Lima
18:00 Discussion

8th day
9:30 "Funny" optics. Ideas for Science Fairs. M. F. Costa, P. Michaelides, B. Vasquez
11:00 Computer simulation on Microsoft Excel. V. Fonseca
14:30 Comenius EU School' cooperation projects. M. F. Costa, P. Michaelides
16:30 Course' evaluation and conclusion
19:30 Farewell dinner

9th day
Departure

(Every day: Coffee break - 11:00 and 16:00; Lunch 12:30; 19:30 Dinner)

Trainers: Professor M. F. M. Costa (University of Minho), Professor B. Dorrio (University of Vigo), Professor P. G. Michaelides (University of Crete), Professor S. Gatt (University of Malta), Dr. D. Sporea (NIPNE), Prof. V. Fonseca (University of Minho). Tutors: Dr. N. Tsaglotis, Dr. R. Batista, Dr. C. Lima, Dr. J. Fernandes.

Figure 2. Program of the "Hands-on Optics" training course

The preparation for the course is considered important [30-31]. The participants receive in advance two Guides for Hands-on Experimental Activities and the Teacher's Handbook, which contains a theoretical presentation on General Optics [32-34]. One of the guides includes 42 experiments, all to be explored during the course, divided into main topics and graded from elementary to secondary level. The other guide call "Continuous" provides a series of observation based investigative activities covering basic light and optics concepts presented in an essentially non-guided way. The essential idea here is not to "show" or present an experiment but yes to induce the discovery process [35].
The follow-up of the course participants is considered of the highest importance. Enquiries and quizzes will be delivered to the teachers, together with support material to be filled by the teachers themselves and their students for a period no shorter than 3 years, to be returned to the course organiser for analysis and statistical treatment. Further training courses on more advanced topics will be made available in a near future [19]. On the other hand we expect the participants to enrol and be active members of the Hands-on Science Network were they will find a mutually supporting and nourishing ground [19].
In Fig. 2 we show the schedule of the two Hands-on Optics training course run in 2009 in Spain and Portugal [35].

Conclusion

The development of optics and photonics requires a large number of well prepared highly motivated scientist and technicians that should be teach and trained as early and as efficiently as possible in a positive rewarding environment. The new stringent requirements of the modern society demand not only the gathering of specific knowledge but also and specially of the competencies the ability of acting interactively to be able to find, analyze and solve new interdisciplinary problems. The best way of achieving an adequate formation of our students on these issues is by inducing the students to an active committed participation in the teaching/learning process, through hands-on investigative practice and experimentation.
Teacher training activities on the hands-on investigative experiments based learning of optics in all school levels and in informal contexts should widely promoted and disseminated.

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